Postharvest Technology

Definition

►The field of post harvest technology is concerned with the study and application of methods to maintain the quality of harvested commodities in order to prevent losses.

►Post harvest technology is a set of handling practices and application that protect the quality of fresh fruits and vegetables from the time of harvest until the time of consumption.

Objectives

1. To reduce loss in quantity or volume and in the qualitative or nutritive value of the product.
2. To maintain the good quality of the produce (color, taste, flavor, aroma).
3. To increases the shelf life of the crops.
4. To keep the fruits or vegetables or commodity free from insect and pest.
5. To get vegetables and fruits fresh all the year round.

Quality of post harvest product

Post harvest quality represents market quality, edible quality, transport quality, table quality, nutritional quality, internal quality and appearance quality. Quality means a combination of characteristics, attributes and properties that gives the values to human and enjoyments. Consumers consider good quality in relation to colour, flavour and nutrition. Quality of the produce is the final manifestation of inter-relation between the commodity and its environment. The genetic characteristics and physiological status of the commodity determine the typical post-harvest behavior and quality of the produce and these two are the major bases for the interaction. Pre-harvest factors viz. environmental factors such as temperature, relative humidity, water potential, light, cultural practices and pest management techniques determined the inherent quality of the produce. However, the ultimate quality is the final manifestation of inter relation between the commodity and its environment.

Several pre-harvest and post-harvest factors affect the quality of horticultural crops. Some of these factors are related to plant, others are related to environment or to cultural practices.

A. Pre-harvest factors

a) Related to plants

1. **Crops:** Quality of the fruit and vegetables are varies from crop to crop. e.g. jackfruit, bael, potato, onion, pumpkin, garlic etc. having good quality in relation to shelf life while apple, mango, cherry, strawberry, tomato, capsicum, okra, brussels sprout, chinese cabbage, carrot, radish attract more to consumers due to their attractive appearance.
2. **Cultivars:** The quality of seed or plant material is an important factor that controls the quality of the fruit and vegetable produced. Several parameters of quality are controlled genetically.
3. **Cultural practices:** All cultural practices have direct effect on the final quality of the produce.
4. **Planting period:** Many plants are very sensitive to environmental conditions and thus quality will not be optimized when crop is produced under adverse conditions. Producing summer plants during the winter or vice-versa will not be appropriate, unless protection practices are implemented.
5. **Planting density:** It affects both the quantity and quality of the produce. High density planting increases competition between plants, reduces light availability, and thus may decrease quantity. Low density planting lead to large size, better colored fruit or vegetable which may have shorter shelf life. Larger fruits are commonly more sensitive to physiological disorders.
6. **Irrigation:** Irregular watering usually reduces fruit size, increases splitting, physiological disorders, reduces water content in the plant or plant part etc.
7. **Fertilization:** Poor management of fertilizers will increase physiological disorders due to deficiencies of some minerals or increase of other leading to toxicity. In both cases, quality will be negatively affected. The application of Ca and high fruit Ca concentration resulted in increased firmness, reduced disease incidence, chilling injury, physiological disorders and ripening and improved storability. Application of excess N element is detrimental in terms of quality attributes.
8. **Pruning:** It reduces the load and increases the growth of fruit and chemical use after harvest.
9. **Thinning:** This operation reduces the competition between fruits or plants and thus promotes a good balance between the vegetative and fruit parts and improves quality.
10. **Protection:** Pathogens and insects have a very negative effect on quality. Poor management of plant protection programmes can lead to very poor quality and reduced yield.

b) Related to Environments

1. **Temperature:** Temperature is the most important environmental factor that affects quality, very low or very high temperature may injure sensitive crops. Temperature has been found to influence fruit shape, size, colour and other quality parameters. Pineapple fruits grown in winter months or in cool growing areas had reduced eating qualities due to lower sugar/acid ratio. Adequate high intensity and quality is important for the formation of some colour. Wind and rain may cause negative effects on some crops.

2. **Radiation:** Radiation interception by fruit has marked effect on the quality attributes of fruits. Any factor that reduces radiation interception results in reduced soluble solids, higher acidity and abnormal skin color development. Low light intensity can reduce the firmness of fruits at harvest and during storage. Low light intensity increases postharvest disease incidence.

3. **Relative humidity:** Relative humidity plays an important role in determining fruit quality. Higher relative humidity reduces of water and Calcium movement into the fruit. In contrast, higher relative humidity around the plant increases calcium accumulation into the fruit by reducing leaf evapotranspiration.

c) Related to Chemicals

1. **Plant Growth Regulator (PGR):** Many hormones and growth regulators are used in agriculture and they can affect quality in different ways. which include gibberellins, cytokinin, auxins. Application of gibberellins during fruit development increased fruit weight. Cytokinin and auxin have been reported to increase shelf life and reduced fruit splitting in persimmon and citrus, respectively.

B) During harvest factor

1. **Season:** Quality of produce are greatly influenced by season. e.g. Winter season harvest having more shelf life as compared to other season while off season fruits and vegetables give more remunerative price. Harvesting during or immediately after rains should not be carried out since it creates most favourable conditions for multiplication of micro organisms. Citrus fruits become susceptible to damage if harvested during rains as their rind becomes turgid and prone to easy bruising, sun-scald etc.

2. **Time:** Fruits and vegetables should always be harvested when temperature is mild. Because, higher temperature leads to faster respiration. Morning harvest of horticultural crop prefer for local market because they are fully fresh and turgid and having dew drop in this time. Evening harvesting is preferred for distant market due to higher accumulation of reserved carbohydrates and less amount of moisture which give the better quality of the produce to consumer. Leafy vegetables harvested in the latter part of the morning or late in the afternoon, the petioles of these vegetables break less easily and their leaves are more

resistant to tearing, since they have lost water through transpiration and therefore are less brittle. Cucumber is harvested in the late morning when it to be transported under less than ideal condition because it is less prone to injury when it contains less water.

3. **Method of harvesting:** Selection of suitable method for harvesting of the produce is necessary otherwise bruises or injuries during harvesting may later manifest as black or brown patches making them unattractive. Latex coming out of stem in mango should not be allowed to fall on fruits as it creates a black spot. Injury to peel may become an entry point for microorganisms, causing rotting. Some harvesting gadgets have been developed, e.g. mango harvester.

4. **Stage of harvesting:** Fruits and vegetables must be harvested at right stage of maturity. A very common cause of poor product quality at harvest and rapid deterioration thereafter is harvesting immature vegetables. Vegetables harvested immature or over mature usually do not keep long. Fruit, vegetables harvested too early lose water fast and are more susceptible to mechanical damage and microbial attack. An over mature vegetable is more susceptible to decay, has passed its best eating quality and deteriorates fast. The stage of maturity and harvest affects fruit quality. Generally, the fruits harvested at the advanced stage of maturity have increased fruits size and eating qualities (taste and aroma) but decreased shelf life. e.g. mango fruits are harvested 7 days before optimum maturity showed better storage performance but failed to arrest skin discoloration, and caused even ripening.

5. **Consumer demand:** Harvesting time and harvest maturity can be altered by the requirement of the consumer's demand which may affect the quality of the produce at some extent.

c) Post-harvest factors

1. **Curing:** Curing is done immediately after harvesting. It strengthens the skin. The process is induced at relatively higher temperature and humidity, involving suberization of outer tissues followed by the development of wound periderm which acts as an effective barrier against infection and water loss. It is favoured by high temperature and high humidity. Potato, sweet potato, colocasia, onion and garlic are cured prior to storage or marketing. Potato tubers are held at 18°C for 2 days and then at 7°—10°C for 10—12 days at 90% relative humidity. Curing also reduces the moisture content especially in onion and garlic. Drying of superficial leaves of onion bulbs protects them from microbial infection in storage.

2. **Degreening:** It is the process of decomposing green pigment (Chlorophyll) in fruits usually applying ethylene or similar metabolic inducers to fruit. It is applicable to banana, citrus and tomato. Degreening is carried out in special treating rooms with controlled temperature and humidity in which low concentration of ethylene (20 ppm) is applied.

3. **Pre-cooling:** High temperatures are detrimental to keeping quality of fruits and vegetables, especially when harvesting is done during hot days. Pre-cooling is a means of removing the field heat. It slows down the rate of respiration, minimizes susceptibility to attack of micro-organisms, and reduces water loss. Peas and okra which deteriorate fast need prompt pre-cooling.

Causes of post-harvest losses

Horticultural crops not only provide nutritional and healthy foods to human beings, but also generate a considerable cash income for growers. However, horticultural crops typically have high moisture content, tender texture and high perishability. If not handled properly, a high-value nutritious product can deteriorate and rot in a matter of days or hours. The causes of post-harvest losses can be divided into different categories:

1. Metabolic

All fresh horticultural crops are live organs. The natural process of respiration involves the breakdown of food reserves and the aging of these organs.

2. Mechanical

Owing to their tender texture and high moisture content, fresh fruits and vegetables are very susceptible to mechanical injury. Poor handling, unsuitable containers, improper packaging and transportation can easily cause bruising, cutting, breaking, impact wounding and other forms of injury.

3. Developmental

These include sprouting, rooting, seed germination, which lead to deterioration in quality and nutritional value.

4. Parasitic diseases

High post-harvest losses are caused by the invasion of fungi, bacteria, insects and other organisms. Micro-organisms attack fresh produce easily and spread quickly, because the produce does not have much of a natural defense mechanism and has plenty of nutrients and moisture to support microbial growth.

5. Physiological deterioration

Fruits and vegetable cells are still alive after harvest and continue their physiological activity. Physiological disorders may occur due to mineral deficiency, low or high temperature injury or undesirable atmospheric conditions, such as high humidity, physiological deterioration can also occur spontaneously by enzymatic action leading to over-ripeness and senescence, a simple aging phenomenon.

6. Lack of market demand

Poor planning or inaccurate production and market information may lead to over production of certain fruits or vegetables which can't be sold in time. This situation occurs most frequently in areas where transportation and storage facilities are inadequate. Produce may lie rotting in production areas, if farmers are unable to transport it to people who need it in distant locations.

7. Consumption

These losses can be due to inadequate preservation methods at home, methods of cooking and preparation such as peeling, consumption styles etc.

8. Others

- Lack of clear concept of packing house operations.
- Lack of awareness among the growers, contractors and even the policy makers.
- Lack of infrastructure.
- Late realization of its importance,
- Inadequate technical support.
- Wide gap in technologies available and in vogue.
- Inadequate post-harvest quality control.
- Unorganized marketing.
- Absence of pre-cooling and cold storage.
- Inadequate market facilities, market intelligence and market information service (MIS).
- Poor storage facilities.

The importance of post-harvest losses

Time and money are required to cultivate food products, and unless the farmer is providing food only for his own household, he automatically becomes part of the market economy: he must sell his produce, he must recover his costs, and he must make a profit.

Estimates of the post-harvest losses of food grains in the developing world from mishandling, spoilage and pest infestation are put at 25%; this means that one-quarter of what is produced never reaches the consumer for whom it was grown, and the effort and money required to produce it are lost-forever. Fruit, vegetables and root crops are much less hardy and are mostly quickly perishable, and if care is not taken in their harvesting, handling and transport, they will soon decay and become unfit for human consumption. Estimates of production

losses in developing countries are hard to judge, but some authorities put losses of sweet potatoes, plantain, tomatoes, bananas and citrus fruit sometimes as high as SO percent, or half of what is grown. Reduction in this wastage, particularly if it can economically be avoided, would be of great significance to growers and consumers alike.

Effects of post-harvest losses

Both quantitative and qualitative food losses of extremely variable magnitude occur at all stages in the post-harvest system from harvesting, through handling, storage, processing and marketing to final delivery to the consumer.

Nutrition

Fruits and vegetables are rich source of vitamins and minerals essential for human nutrition. These are wasted in transit from harvest to consumer represent a loss in the quantity of a valuable food. This is important not only in quantitative terms, but also from the point of view of quality nutrition. Reducing Postharvest losses along all segments of fruit and vegetable value chains presents an opportunity to improve nutrition security by capturing otherwise lost nutrients to channel into the food system and create profitable, accessible and affordable diversified diets.

Economy

Careless harvesting and rough handling of perishable bruise and scar the skin, thus reducing quality and market price. Such damaged produce also fails to attract the international buyers, and bring the exporting country less profit and bad name. This ultimately results in huge economic losses to the country.

For improving the situation, it is essential to create awareness among growers, farm workers, manager's traders and exporters about the extent of losses being incurred and their economic consequences. These groups of people involved in the fruit industry also need to learn the basic principles of fruit handling and storage. In addition, the government needs to provide basic infra-structure like storage, handling, grading, packing, transport and marketing facilities and technical expertise. This could be carried out by the public and private sectors.

Loss assessment

There are no generally accepted methods for evaluating post-harvest losses of fresh produce. Whatever evaluation method may be used, the result can refer only to the described situation.

In the appraisal of an existing marketing operation, the accurate evaluation of losses occurring is a problem. It may be suspected that losses are too great, but there may be no figures to support this view because:

- Records do not exist;
- Records if available do not cover a long enough period of time;
- The figures available are only estimates made by several observers;
- Records may not truly represent a continuing situation; for example, losses may have been calculated only when unusually high or low;
- Loss figures may be deliberately over- or understated for commercial or other reasons in order to gain benefits or to avoid embarrassment.

Consequently, if accurate records of losses at various stages of the marketing operation have not been kept over a period of time, a reliable assessment of the potential cost-effectiveness of ways to improve handling methods is virtually impossible, and the marketing position of the grower is difficult to strengthen. It is evident that the grower who wants to reduce his post-harvest losses must maintain reliable records.

Technologies for minimizing the losses

Fruits and vegetables are perishable in nature. Scientific harvesting and handling are the practical way to reduce the losses due to physical damage, spoilages, due to insect damages and microbial growth. Various protocols are standardized and available for adoption to get the best result, which will give economic benefits. Similarly, proper storage conditions, with suitable temperature and humidity are needed to lengthen the storage life and maintain quality once the crop has been cooled to the optimum storage tempera Lure. Greater emphasis need to be given on the training of farmers, creation of infrastructure for cold chain with common facilities for sorting, grading, packing and post harvest treatments in all major markets. Some technologies for extension of shelf life of fruits and vegetables are:

1. **Waxing:** It is used as protective coating for fruits and vegetables and help in reduction in loss in moisture and rate of respiration and ultimately results in prolonged storage life.

2. **Evaporative cool storage:** It is the best short-term storage of fruits and vegetables at farm level. It helps the farmers to get better returns for their produce. In this structure, horticultural crops reduce shriveling and extend their storage life.

3. **Pre-packaging:** This technology controls the rate of transpiration and respiration and hence keeps the commodity in fresh condition both at ambient and low temperature. It can able to bring revolutionary progress in our trade practice and also benefit the consumer and the producer because of its low cost and ready availability.

4. **Cold storage:** These structures are extensively used to store fruits and vegetables for a long period and employ the principle of maintaining a low temperature, which reduces the rate of respiration and thus delays ripening.

5. **Modified atmosphere packaging (MAP):** These packaging modify the atmosphere composition inside the package by respiration. This technology is successful to extend the shelf life of (Cavendish banana, carrots capsicum, green chilli and tomatoes by 15, 14, 13, 8 and 15 clays as against 5, 7, 8, 4 and 7 days in control respectively, under ambient conditions. Storage of Papaya can be extended 4 weeks when stored at 10 -12°C under modified atmosphere (MA) conditions by wrapping them in low density polyethylene (LDPE) bag. Using this technique, the fruit can be transported to different markets in refrigerated sea containers with Temperature Sea at 10-12°C. Fruits ripen within 3-4 days after arrival when placed at ambient temperature. While using optimum low temperature, storage life of Cavendish banana, capsicum, green chili and tomato can be extended to 42, 21, 28 and 30 days in comparison to 21, 10, 21 and 15 days respectively.

6. **Controlled Atmosphere (CA) storage:** It is based, on the principle of maintaining an artificial atmosphere in storage room, which has higher concentration of CO_2 and lower concentration of O_2 than normal atmosphere. This reduces the rate of respiration and thus delays aging. This method of storage is very effective when combined with low temperature storage.

7. **Cold chain:** Following cold chain handling system for fresh horticultural crops from arm to consumer. It helps in reducing wastages and retention of quality of commodities.

8. **Irradiation:** It is the newer technologies that can be gainfully employed during storage to reduce post-harvest losses and extend storage life of fruits and vegetable. When fruits and vegetables expose to ionizing radiation (such as gamma-rays) at optimum dosage delays ripening minimizes insect infestation, retards microbial spoilages, control sprouting, and rotting of onion, garlic and potato during storage. It is also used as a disinfection treatment and controls fruit fly on citrus, mango seed weevil and papaya fruit fly.

9. **Edible coatings:** These are continuous matrices prepared from edible materials such as proteins, polysaccharides and lipids. They can be used as film wraps and when consumed with the food, become an ingredient of the food. They not only minimize the post harvest losses but also need for energy intensive operations and controlled atmosphere storage. They can control migration of gases, moisture, oil, fat, and solutes, as well as retain volatile flavouring compounds. An edible coating improves structural integrity and mechanical handling and carry product so that they help to maintain quality and inhibit microbial growth causing deterioration of the product.

10. **Others:**

- Facilities/services like grading, washing, cleaning, scientific harvesting and the like, in respect of perishables at the farm level.

- Cold storage facilities should be extended to tropical fruits and vegetables.
- Handling protocols should be established for crops other than mango, citrus, grapes and capsicurn to improve the shelf life and export.
- The issue relating to increasing the shelf life of horticultural products needs to he addressed.
- Appropriate packaging material for export of fresh fruits, vegetables and for modified atmosphere packaging should be developed.
- Value addition needs to be viewed in a wider perspective than mere processing to ensure better return to the producer/farmer, besides providing better quality product to the consumer.
- Development of natural food columns, fiber, single cell protein and food grade enzymes from processing wastes will be useful.